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LHC-DFBX
CRITERIA FOR ACCEPTANCE OF THE DFBX
FROM THE VENDOR BY LBNL

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History of Changes

<i>Rev. No.</i>	<i>Date</i>	<i>Pages</i>	<i>Description of Changes</i>
A	2003-03-03	5	Section 2 Paragraph 2.1.1.2 and 2.1.2.3, Helium Tank Weld Inspection: Limited radiograph tests to the shells longitudinal welds
A	2003-03-03	5	Section 2 Paragraph 2.1.7.1, Measure and record movement of center of top plate during end plate welding: Deleted the 0.75 mm requirement
A	2003-03-03	5	Section 2 Paragraph 2.2.2.1, Helium vessel cold shock: Cold shock process shall be submitted to LBNL for approval
A	2003-03-03	7	Section 3 Paragraph 3.2.1 Leak Checks and Pressure Tests: Deleted "snoop " test requirement
A	2003-03-03	8	Section 3 Paragraph 3.3.1 Preparation for Shipping: System could be manifolded together to backfill circuits with dry N2

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CRITERIA FOR ACCEPTANCE OF THE DFBX FROM THE VENDOR BY LBNL

This document defines the acceptance criteria for the fabrication and integration of eight feedboxes, DFBX. It outlines the essential dimensional checks, pressure and leak checks, and electrical tests that must be done on the feedboxes subassemblies during fabrication and assembly process. This document also specifies the required checks of the feedbox and its shipping package before shipping to CERN and after shipping is complete at the CERN's receiving dock. LBNL will accept the DFBX from the cryogenic system fabricator after the feedbox and its shipping package have successfully passed the required checks at CERN's receiving dock.

Records and documents which form part of the deliverables are indicated in **bold type**. Drawings and dimensions referenced in this document are for the DFBX-G/C box. Corresponding drawings for the other boxes are referred to here as follows:

Box name	DFBX-G/C	DFBX-A	DFBX-B	DFBX-D/H	DFBX-E	DFBX-F
Top level assembly	24c352	24c351	24c350	24c362	24c394	24c395
Major assembly	25i137	25i150	25i154	25i144	25i151	25i155
Piping assembly	25i226	25i872	25i871	25i235	25i873	25i874
Electrical wiring	25i619 / 25i615	25i613	25i614	25i616/ 25i620	25i617	25i618

1. Pre-Approval of Test Procedures:

The subcontractor must submit the following procedures for review and approval by LBNL prior to their implementation.

- 1.1 Mechanical measurement methods for the critical dimension checks listed below
- 1.2 General vacuum leak check procedure
- 1.3 Specific pressure test procedures including flow schematics
- 1.4 General electrical continuity test method
- 1.5 General hipot test method

2. Requirements During Assembly

2.1. Document ASME Pressure Vessel compliance, piping and vessel mechanical integrity, and certain critical dimensions

2.1.1. Manufacture and weld helium tank in accordance with ASME Pressure Vessel Code, Section 8, with the exception of the final close-out weld of the access panel.

Document each of the following:

2.1.1.1. Welders', material, and equipment certificates required by the ASME Pressure Vessel Code

2.1.1.2. Radiograph and interpret top and bottom shells longitudinal welds

2.1.1.3. Check access door and non-access door welds with die penetrant

2.1.1.4. 4K Charpy impact tests as required: minimum absorbed energy 22 ft-lb (38 J)

2.1.2. **Document that pipes and flex hoses are sized (diameter and wall thickness) as required in drawing 25i226 and associated drawings. Document pipe material and weld filler material.**

2.1.3. Check that each piping assembly is free of obstructions after final weld

2.1.3.1. Inspect pipes with a bore scope

2.1.3.2. Where a bore scope inspection is not practical, verification by means of a flow test is acceptable (for a flow test, LBNL will provide a flow rate and pressure drop requirement)

2.1.4. **Document conformance to a few critical dimensional requirements at completion of helium tank attachment to chimneys and top plate**

2.1.4.1. Measure lead chimney straightness: deviations should be < 1 mm. (Reference: drawing 25i137)

2.1.4.2. Check that all lead chimney bellows offsets < 0.5 mm. (Reference: drawing 25i137)

2.1.5. **Document conformance to a few critical dimensional requirements after helium tank has been closed**

2.1.5.1. Check that all lead chimney bellows offsets < 1 mm. Photograph the lead chimney bellows, chimneys and helium vessel.

2.1.6. Visual inspection of pipe clearances after installation of pipe assemblies

2.1.6.1. Check that the minimum clearance from any pipe to any other ≥ 12 mm.

Document piping assembly with photos.

2.1.7. Top plate distortion

2.1.7.1. **Measure and record movement of center of top plate during end plate welding.**

2.1.8. **Measure and record positions of MQX1 and MBX1 ducts with respect to the beam pipe** via the fiducials on the top plate (ref: 24c352, sheet 8) after end and bottom plates have been welded and helium vessel supports are complete

2.2. Leak Checks and Pressure Tests

2.2.1. Cold shock, pressure test, and leak check (in that order) each piping assembly after final weld

2.2.1.1. Cold shock to $T \leq 80$ K, warm to $T \geq 0$ C (frost-free).

2.2.1.2. Pressure test pipes to the pressures listed in Appendix Table A-1. **Provide written confirmation of pressure test.**

- 2.2.1.3. Leak check each piping assembly, leak rate $< 1 \times 10^{-9}$ atm cc/sec. **Document each leak test result.**
- 2.2.2. After helium tank has been closed
- 2.2.2.1. Cold shock He tank to $T \leq 80$ K, warm to $T \geq 0$ C (frost free). Cold shock process allowing for either spraying individual welds or by filling the helium tank with LN2 must be submitted to LBNL for approval.
- 2.2.2.2. Pressure test bus ducts to 2.5 MPa (with helium tank pressure at 0.1 MPa) for 600 sec; see Appendix Figure A-2 for a suggested pressure test schematic. **Provide written confirmation of pressure test.**
- 2.2.2.3. Pressure test He tank and bus ducts together to 0.54 MPa for 600 sec; see Appendix Figure A-2 for a suggested pressure test schematic. **Provide written confirmation of pressure test.**
- 2.2.2.4. **Measure and record lambda plug leak rate** with $\Delta P = 0.1$ MPa equal to the value measured at LBL $\pm 30\%$; see Appendix Figure A-2 for a suggested lambda plug leak measurement schematic.
- 2.2.2.5. Leak check helium tank and bus duct assembly, vacuum leak rate $< 3 \times 10^{-9}$ atm cc/sec; see Appendix Figure A-3 for a suggested leak test schematic. **Provide leak check documentation.**
- 2.2.3. Pressure test and final leak check of MQX2 and MBX2 lines after welding to vacuum vessel top plate
- 2.2.3.1. 2.5 MPa pressure must be held, with pipes sealed, with no visible drop for 10 minutes. **Provide written confirmation of pressure test.**
- 2.2.3.2. Leak check weld of MQX2 and MBX2 lines to the vacuum vessel top plate, leak rate into the insulating vacuum space $< 1 \times 10^{-9}$ atm cc/sec. **Provide leak check documentation.**
- 2.3. Electrical Tests (refer to LBL electrical schematic, drawing # 25i615)**
- 2.3.1. After installation of power leads and busses, with helium tank open
- 2.3.1.1. **Confirm and document continuity of all leads**
- 2.3.1.2. **Measure and record electrical resistance of temperature sensors, a 4-wire measurement.** Temperature sensor resistances should match the specified values to ± 5 ohms.
- 2.3.1.3. Hipot HTS lead heaters at 300 V, $I < 3 \mu A$. **Record leakage current.**
- 2.3.1.4. **Confirm and document continuity of power lead voltage taps**
- 2.3.1.5. **Measure and record electrical resistance of helium tank instrumentation** (liquid level sensors, temperature sensors, tank heaters). Temperature sensor resistances should match the specified values to ± 5 ohms.
- 2.3.2. After helium tank has been closed
- 2.3.2.1. Hipot leads and busses, temperature sensors, and helium tank instrumentation in room temperature, 1 bar helium. See Appendix Figure A-4 for a helium hipot schematic. **Record leakage current.**
- 2.3.2.1.1. 7500 A leads: 1.4 kV, $I < 15 \mu A$
- 2.3.2.1.2. 600 A leads: 0.65 kV, $I < 7 \mu A$
- 2.3.2.1.3. 120 A leads: 0.65 kV, $I < 7 \mu A$

- 2.3.2.1.4. HTS lead temperature sensors: 120 V, $I < 1 \mu\text{A}$
- 2.3.2.1.5. He tank instrumentation: 200 V, $I < 2 \mu\text{A}$
- 2.3.3. After magnet instrumentation ducts (MQX2 and MBX2) have been installed and wired.
 - 2.3.3.1. **Check and document continuity from connectors at magnet end to DFBX feedthrough.**
 - 2.3.3.2. Hipot MQX2 and MBX2 wires in 1 atm helium. **Record leakage current**
 - 2.3.3.2.1. Voltage tap leads: 1.4 kV, $I < 15 \mu\text{A}$
 - 2.3.3.2.2. Quench heater leads: 1.4 kV, $I < 15 \mu\text{A}$
 - 2.3.3.2.3. Warm-up heater leads: 650 V, $I < 7 \mu\text{A}$
 - 2.3.3.2.4. Temperature sensor leads: 200 V, $I < 2 \mu\text{A}$
- 2.3.4. Electrical tests of passive heater temperature sensors
 - 2.3.4.1. **Measure and record electrical resistance of temperature sensors, a 4-wire measurement.** Temperature sensor resistances should match the specified values to ± 5 ohms.
 - 2.3.4.2. Hipot: 200 V, $I < 2 \mu\text{A}$. **Record leakage current**

3. Tests of Completed Assembly and Tests Just Prior to Shipment

All dimensions and tolerances shown on the fabrication drawings apply at reference temperature of 20 C (68 F).

3.1. Document Critical Dimensions

- 3.1.1. Measure and record positions (x,y,z) of the two Taylor Hobson spheres with respect to datum planes B, E, and D, respectively. (See drawing 24c352 for datum definitions and required dimensions.)
- 3.1.2. Measure and record roll angle of the top plate tooling flat about y-axis relative to datum plane D. (See drawing 24c352, sheet 11)
- 3.1.3. Verify and record Q3 interface vacuum flange and pipe positions per drawing 24c352, sheet 8. Since pipes positions are flexible, shim pipes to the center of the support arc (typically 8 mm of radial clearance) in the G-10 support spider and hold them parallel to the y-axis (box long axis) for this measurement.
- 3.1.4. Verify and record D1 interface vacuum flange and pipe positions per drawing 24c352, sheet 8. Since pipes positions are flexible, shim pipes to the center of the support arc (typically 8 mm of radial clearance) in the G-10 support spider and hold them parallel to the y-axis (box long axis) for this measurement.
- 3.1.5. Verify and record JC1 and JC2 (jumper) interface vacuum flange and pipe positions per drawing 24c352, sheet 7. Since pipes positions are flexible, shim pipes to the center of their support range and in a straight (parallel to x-axis) position for this measurement.

3.2. Leak Checks and Pressure Tests

- 3.2.1. Pressure test vacuum vessel: hold $P = 0.14 \text{ MPa}$ for 600 sec. **Provide written confirmation of pressure test.**
- 3.2.2. Leak check vacuum vessel: leak rate $< 10^{-8} \text{ atm cc/sec}$. **Provide leak check documentation.**

3.2.3. Leak check helium tank and bus ducts: helium tank and bus ducts filled with helium at $P = 0.12$ MPa, leak rate to insulating vacuum $< 3 \times 10^{-9}$ atm cc/s. **Provide leak check documentation.**

3.2.4. Leak check piping: pressurize with helium to 0.3 MPa, leak rate to insulating vacuum $< 3 \times 10^{-9}$ atm cc/s. **Provide leak check documentation.**

3.3. Preparation for Shipment

3.3.1. Backfill all circuits (vacuum vessel, helium vessel, all pipes) with dry nitrogen at 0.12 MPa (3 psig) and seal. System could be manifolded together to allow for a single supply line to pressurize the system. **Record the pressure in each circuit to ± 0.5 psi.**

3.3.2. **Record ambient temperature and pressure at time of feedbox pressurization**

3.3.3. Zero the shock indicators

3.3.4. **Record the ambient temperature and pressure at time of feedbox packing**

4. Tests at CERN After Shipping

(these test for acceptance by LBNL from the vendor, tests performed by LBNL or designee)

4.1. Subcontractor must provide any unique tools such as templates or manifolds manufactured specifically to perform DFBX acceptance tests which are needed to perform the following acceptance tests at CERN.

4.2. **Document the following observations concerning container and vessel mechanical integrity**

4.2.1. Visually inspect shipping container and/or shipping crate prior to unloading from truck

4.2.2. Note maximum accelerations recorded during shipment and verify that they are less than maxima specified in Shipping Specification

4.2.3. Note and record pressures in the vacuum vessel, helium vessel, and piping.

4.3. Leak Checks and Pressure Tests

4.3.1. Leak check the vacuum vessel: leak rate $< 1 \times 10^{-8}$ atm cc/sec. **Provide leak check documentation.**

4.3.2. Pressure test bus ducts to 2.5 MPa (while pressure in the helium tank is 0.1 MPa) for 600 sec. **Provide written record of pressure test.**

4.3.3. Pressure test He tank to 0.54 MPa for 600 sec. **Provide written record of pressure test.**

4.3.4. Pressure test internal pipes at pressures listed in Appendix Table A-1; hold for 10 minutes. **Provide written record of pressure test.**

4.3.5. Leak check the helium tank and bus duct: leak rate to insulating vacuum $< 3 \times 10^{-9}$ atm cc/s. **Provide leak check documentation.**

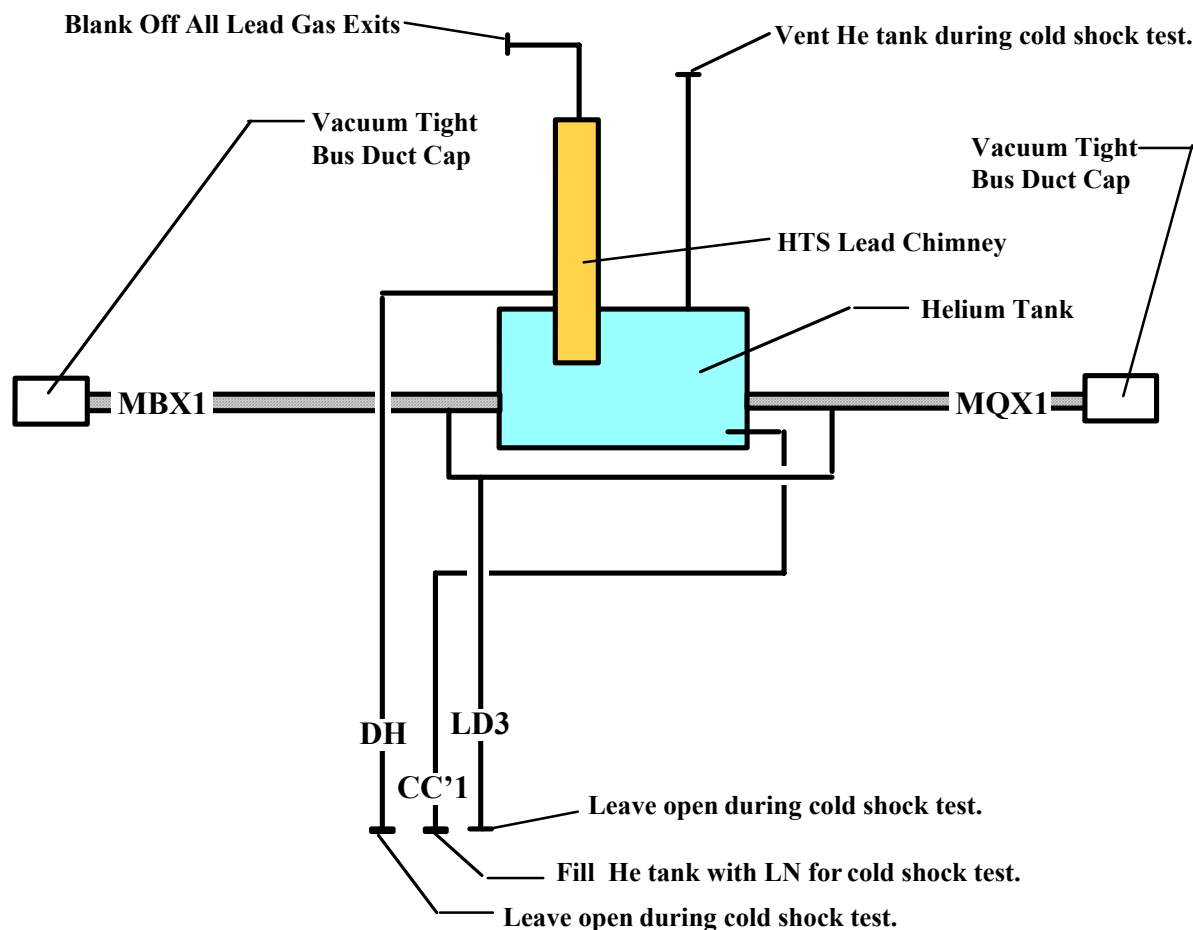
4.3.6. Leak check pipes to insulating vacuum to a level $< 3 \times 10^{-9}$ atm cc/s with 0.3 MPa helium pressure in the lines. **Provide leak check documentation.**

4.4. Measure and Record Vacuum Flange and Pipe Positions.

- 4.4.1. Measure and record positions (x,y,z) of the two Taylor Hobson spheres with respect to datum planes B, E, and D, respectively. (See drawing 24c352 for datum definitions and required dimensions.)
- 4.4.2. Measure and record roll angle of the top plate tooling flat about y-axis relative to datum plane D. (See drawing 24c352, sheet 11)
- 4.4.3. Verify and record Q3 interface vacuum flange and pipe positions per drawing 24c352, sheet 8. Since pipes positions are flexible, shim pipes to the center of the support arc (typically 8 mm of radial clearance) in the G-10 support spider and hold them parallel to the y-axis (box long axis) for this measurement.
- 4.4.4. Verify and record D1 interface vacuum flange and pipe positions per drawing 24c352, sheet 8. Since pipes positions are flexible, shim pipes to the center of the support arc (typically 8 mm of radial clearance) in the G-10 support spider and hold them parallel to the y-axis (box long axis) for this measurement.
- 4.4.5. Verify and record JC1 and JC2 (jumper) interface vacuum flange and pipe positions per drawing 24c352, sheet 7. Since pipes positions are flexible, shim pipes to the center of their support range and in a straight (parallel to x-axis) position for this measurement.

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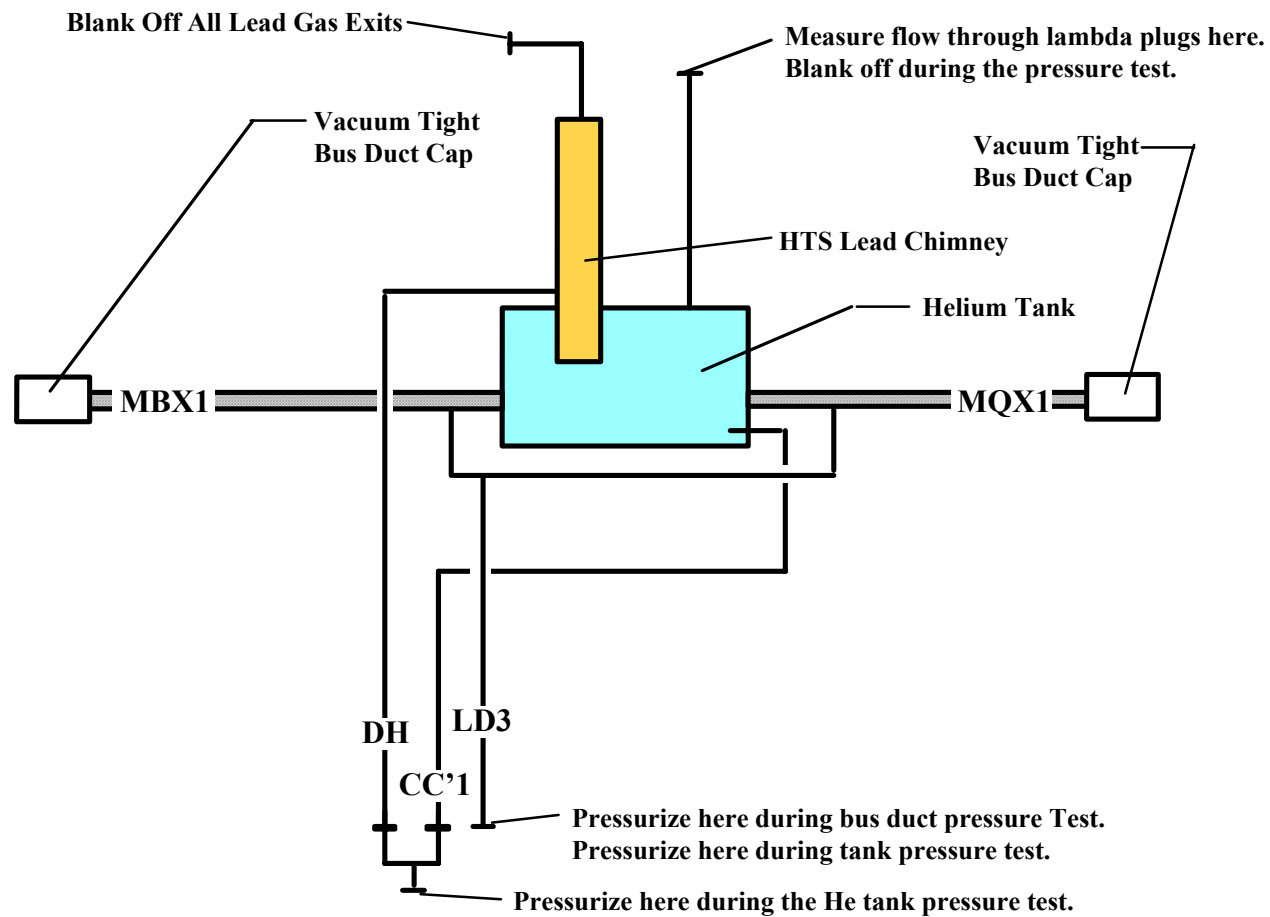
Figure A-1. Cold shock schematic



Note: in order to avoid condensation of water on the bus duct side of the lambda plugs, bus ducts may either be evacuated or backfilled with helium. In either case, a relief should be installed on the bus duct volumes to avoid possible overpressure from a cold leak followed by warm-up.

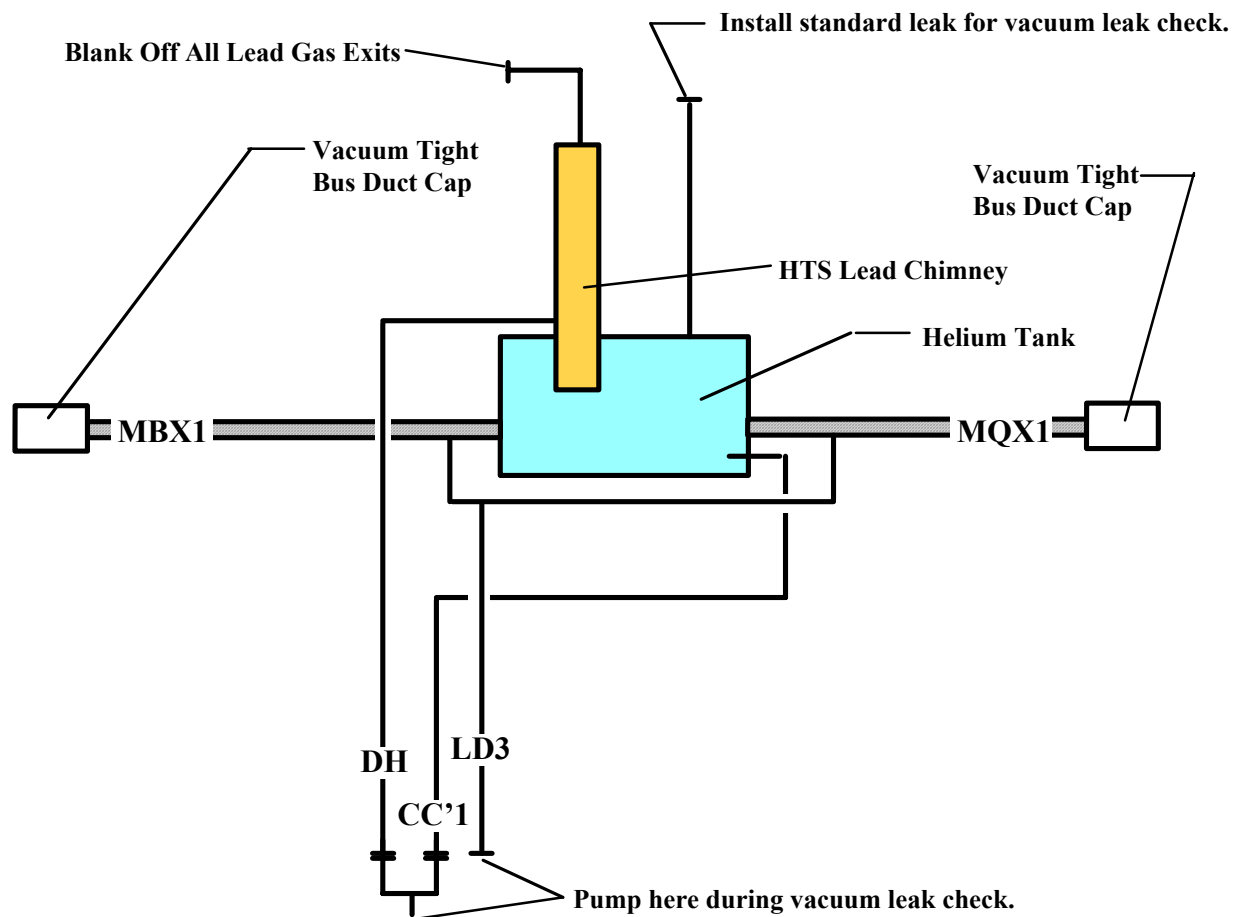
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Figure A-2. Pressure test schematic



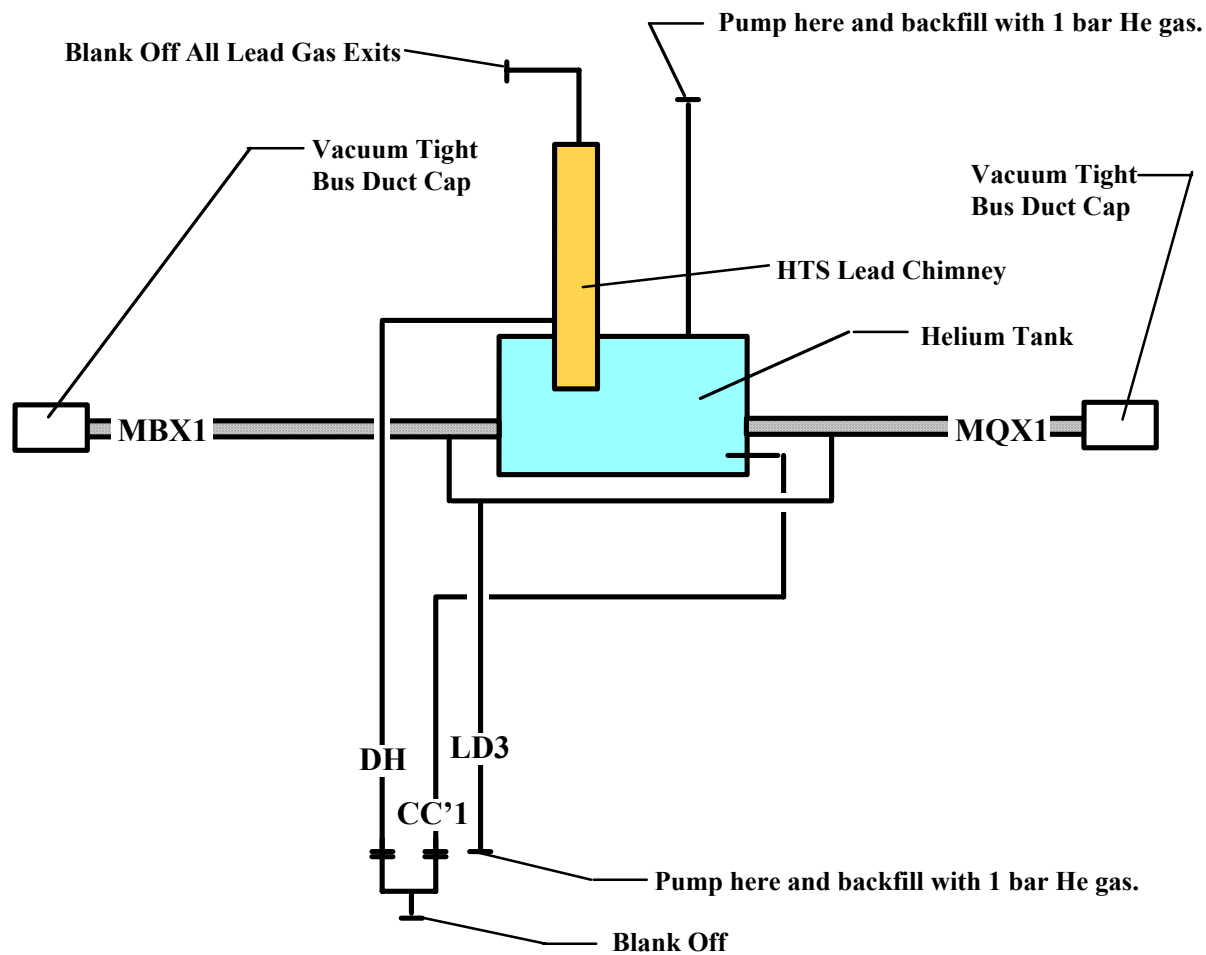
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Figure A-3. Leak check schematic



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Figure A-4. Helium hipot schematic for current leads and bus ducts



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Table A-1. Pipe Test Pressures

Pipe Assembly Designation	LBNL Drawing Number	Minimum Test Pressure	
		(MPa)	(psig)
V (beam tube)	25I206	0.50	73
XB & surge pot	25I890	0.50	73
CY1	25I210	0.50	73
CY2	25I215	0.50	73
CC'1	25I218	2.50	364
CC'2	25I216	2.50	364
CC'3	25I217	2.50	364
DH	25I225	2.50	364
E1	25I209	2.75	400
E2	25I214	2.75	400
EX	25I212	2.75	400
LD1	25I223	2.50	364
LD2	25I208	2.50	364
LD3	25I891	2.50	364
MBX1 (bus duct)	25I213	2.50	364
MQX1 (bus duct)	25I205	2.50	364
MBX2 (instrument conduit)	25I219	2.50	364
MQX2 (instrument conduit)	25I301	2.50	364